

WHAT IS CLAIMED IS:

1. A membrane comprising the cross-linked, polymeric reaction product of a polybenzimidazole and 1,4-C₆H₄XY, wherein X and Y are selected from the group consisting of CH₂Cl, CH₂Br, and CH₂I.
2. The membrane of claim 1, wherein X and Y are CH₂Br.
3. The membrane of claim 1, further comprising a porous support for supporting said cross-linked polymeric reaction product, wherein said porous support comprises a material selected from the group consisting of metal, metal alloy, ceramic material, and combinations thereof.
4. The membrane of claim 1, wherein said polybenzimidazole comprises poly-2,2'-(m-phenylene-5,5'-bibenzimidazole).
5. A cross-linked membrane prepared by layering a solution of solvent, polybenzimidazole and 1,4-C₆H₄XY, wherein X and Y are selected from the group consisting of CH₂Cl, CH₂Br, and CH₂I, on porous support and evaporating the solvent.
6. The membrane of claim 5, wherein the solution comprises 1,4-C₆H₄XY in an amount from greater than zero weight percent to about 45 weight percent based on the weight of polybenzimidazole.
7. A method for gas separation, comprising sending a gas mixture through a membrane comprising cross-linked polybenzimidazole.
8. The method of claim 7, wherein the cross-linked polybenzimidazole is formed by reacting a polybenzimidazole with 1,4-C₆H₄XY, wherein X and Y are selected from the group consisting of CH₂Cl, CH₂Br, and CH₂I.
9. The method of claim 7, wherein the polybenzimidazole comprises poly-2,2'-(m-phenylene)-5,5'-bibenzimidazole.

10. The method of claim 7, wherein the membrane further comprises a porous support comprising a material selected from the group consisting of metals, metal alloys, ceramic materials, and combinations thereof.
11. The method of claim 7, wherein gas mixture comprises at least one gas selected from the group consisting of hydrogen sulfide, SO_2 , COS, carbon monoxide, carbon dioxide, nitrogen, hydrogen, and methane.
12. The method of claim 7, wherein the membrane is heated to a temperature from about 25°C to about 400°C .
13. The method of claim 9, wherein the membrane is heated to a temperature of at least 265°C .
14. A method for separating carbon dioxide from a gas mixture, comprising sending a gas mixture that includes carbon dioxide through a membrane comprising cross-linked polybenzimidazole.
15. The method of claim 14, wherein cross-linked polybenzimidazole comprises the cross-linked, polymeric reaction product of polybenzimidazole with 1,4- $\text{C}_6\text{H}_4\text{XY}$, wherein X and Y are selected from the group consisting of CH_2Cl , CH_2Br , and CH_2I .
16. The method of claim 14, wherein the membrane further comprises a porous support comprising a material selected from the group consisting of metals, metal alloys, ceramic materials, and combinations thereof.
17. The method of claim 14, wherein the gas mixture comprises at least one hydrocarbon.
18. The method of claim 14, wherein the gas mixture comprises methane.
19. The method of claim 14, further comprising heating the membrane to a temperature from about 25°C to about 400°C .
20. The method of claim 14, wherein the cross-linked polybenzimidazole comprises the reaction product of poly-2,2'-(m-phenylene)-5,5'-bibenzimidazole and 1,4- $\text{C}_6\text{H}_4\text{X}_2$ wherein X is CH_2Br .

21. The method of claim 20, wherein the membrane is heated to a temperature of at least 265°C.